

Letters to the Editor.

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The Accessory Nature of many Structures and Habits Associated with Courtship.

A STUDY of mating-habits in birds and other animals has led me to conclusions which perhaps have a general interest as bearing upon the whole theory of sexual selection.

As is well known, the difficulty of understanding how sexual selection could operate in monogamous animals has, together with other objections, led many naturalists to reject it wholly or almost wholly as a factor in evolution. However, whether we reject it or not, there remains a large body of observed facts which is in need of some evolutionary explanation. The facts are (1) that elaborate displays and other ceremonies occur in many animals in connection with mating, and (2) that brilliant colours and special structures are generally developed in these animals, and are employed chiefly or solely in these displays and ceremonies.

Our first and immediate conclusion is that, in view of their elaborate nature and widespread distribution, it is impossible to maintain that all these ceremonies and associated structures are biologically meaningless. Further, in many species the employment of such special structures is *invariably* associated with sexual ceremonies; for example, the ruff and ear-tufts in both sexes of *Podiceps cristatus*, the crested grebe, the elongated scapulars of egrets, or the "tail" of the male peacock. In these cases of invariable association, then, we can be sure, so far as observation alone permits certainty, that both structures and ceremonies have a biological significance in connection with mating. We can, with an almost equal approach to certainty, assign biological significance to such bright colours as are placed so as to be especially conspicuous during sexual ceremonies, e.g. the wing colours and markings of the blackcock and crested grebe, the brightly coloured markings on male spiders, the brilliance of the heads and necks of male birds of paradise, etc. The problem is then to discover *what* the biological significance behind these colours, structures, and ceremonies may be.

That in a large number of instances they cannot have arisen through any process of sexual selection is shown by the fact that in many monogamous birds there exist mating ceremonies, often elaborate, which occur only after pairing-up has taken place for the season. Examples of these are to be seen in the Sylviidae (see E. Howard, "The British Warblers," 1907-14), the crested grebe (Huxley, Proc. Zool. Soc., 1914), apparently the Fringillidae (E. Howard, "Territory in Bird Life," 1920), and in divers and egrets (unpublished observations of my own). It is obvious that sexual selection, i.e. selection by a female as between several potential mates, cannot operate here, since there is only one male and one female involved.

Further light is thrown on the question by the observation quoted in Pycraft's "Courtship of Animals" (Hutchinson, London, 1913) that male newts deposit their spermatophore *before* beginning their "courtship" antics. As a result of the performance, apparently, the female picks up the spermatophore with the lips of her cloaca. It is obvious here that the special ceremony and coloration of the male can

be thought of only as an excitant to induce the female to perform her part in effecting the union of the gametes; if several males were to deposit their spermatophores before a single female, and then all perform their mating antics, there could be no possible agency through which a male with a particularly effective display could succeed in making the female pick up his particular spermatophore rather than another.

This conclusion is fully borne out by the experimental results of Sturtevant upon the dipteran *Drosophila* (quoted by Morgan, Carnegie Institution Publication No. 285, 1919, p. 61). The male of *Drosophila* has a mating ceremony in which he vibrates his wings in front of the female. Sturtevant showed that single males whose wings were cut off would succeed in mating when isolated with single females, but only after an average time considerably longer than that required by normal males. But when a normal male and one deprived of wings were imprisoned together in company with a single female, the wingless male succeeded in mating almost as often as his normal competitor. The so-called "courtship," therefore, is again a stimulant; once the female has been stimulated by the display she is equally ready to mate with any male, whether normal or so mutilated as to be unable to perform the "courtship" action. As Morgan says (*loc. cit.*, p. 61), "This critical test puts the problem in a different relation from that which Darwin's theory of female choice was meant to throw light on."

It appears, therefore, that in these examples—newts, *Drosophila*, and the post-mating ceremonies of monogamous birds—sexual selection cannot be operative. The effect of the ceremonies in these and many other species is not the selection of one rather than another out of several possible mates, but simply a facilitation of the union of the gametes.

Now copulatory organs have exactly this same function. When internal fertilisation is employed, copulatory organs are in the majority of cases developed. They are an adaptation to a particular method of fertilisation. In precisely similar fashion I would say that when organisms possess a certain grade of mental (nervous) development one of two further adaptations is required to facilitate the union of the gametes. Either, as in mammals, a hormone is periodically produced which causes the female at certain times to be ready to take any male, while at other's she refuses all males; in this case displays and ceremonies will be useless, and fighting between males will be the rule. Or else the stimulus to make the female ready to take the male must come from without; it must, therefore, affect the nervous system through the sense-organs, and will generally take the form of a display by the male.

If the female were at all times ready to take the male, excessive coition would occur, which would be deleterious; thus it is desirable that some stimulus, whether endocrine or sensory, internal or external, should be necessary in order that coition may take place.

I have so far purposely simplified the problem by dealing only with those species in which it is the female who needs stimulation, the male who is always or usually ready for coition and performs the special ceremony. The reasoning, however, will equally apply to cases of "reversed sexual selection," such as the Phalarope, where the female is more brightly coloured and the male requires stimulation, or to the numerous cases of "mutual courtship," such as is found in grebes, divers, egrets, herons, the kagu, the fulmar, etc., in which both sexes are brightly coloured,

both play similar rôles in the ceremonies, and apparently both equally need excitation for coition to take place. Here mutual, instead of one-sided, excitation occurs.

It will be evident that wherever mating displays and ceremonies, and the colours and structures associated with them, have this purely stimulative function they cannot be supposed to stand in any relation to sexual selection, but resemble copulatory organs in being solely subservient to efficiency in securing union of the gametes. Copulatory organs will arise only when a certain level of general physical complexity is reached; stimulative displays, colours, and structures only at a certain level of sensory and nervous (mental) complexity.

The problem of their genesis is therefore no more difficult than that of copulatory organs, or, indeed, of any other adaptive structures—which is not to say that it is easy, but that at least it does not demand special evolutionary agencies.

When polygamy obtains, true sexual selection may, of course, occur, and from observations such as those of Selous on the ruff and blackcock (Selous, *Zoologist*, 1906 and 1909-10), does definitely seem to be operative.

To denote characters which are secondarily concerned with bringing about mating or copulation we may use the term "epigamic," first coined by Poulton. It is necessary to have such a term, since "secondary sexual" cannot be applied to epigamic characters occurring in both sexes, and can be applied to non-epigamic characters such as mammæ. Characters effective in the act of copulation itself (copulatory organs) come under the head of "accessory sexual characters." Epigamic characters are then either "accessory," when they stimulate to coition, or "sexually selected," when they stimulate to the selection of mates. In certain cases they may be both. There is, however, good reason for believing that the great bulk of sexual displays, with their associated colours and structures, are accessory epigamic characters, and that the problem of their evolutionary origin is therefore simplified.

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New College, Oxford, December 7.

Terrestrial Magnetic Disturbances and Sun-spots.

REFERRING to Father Cortie's letter on this subject (*NATURE*, October 27, p. 272), the sequence of magnetic disturbances following at 27-day intervals the storms of May 12-21, 1921, was recorded also at Kodaikanal, but those storms recorded in England as "very great" on September 2 and 28-29 were classed here as "moderate" only. There were also recorded here "great" storms on March 21-22 and April 18-19, which appear to belong to the same sequence, the whole interval from March 22 to September 29 giving a mean period of 27.29 days. Assuming this to be the synodical period of the sun, the equivalent sidereal period is 25.42 days, closely agreeing with Carrington's mean value of the rotation for spots.

Our spectroheliogram records show that the spot disturbance originated on the invisible hemisphere of the sun shortly before May 8, when it first appeared on the east limb as a condensed mass of bright calcium flocculi. As is usually the case, the area of disturbance became extended; in July the flocculi were more or less scattered, and the last visible remnants of these are seen in the photographs of August 1-8.

The magnetic disturbances seem therefore to have both preceded and followed the spot disturbance as

recorded in calcium light, the flocculi lasting through three synodic rotations and the magnetic effects through seven.

Except during May, there were no striking manifestations of prominence activity recorded here near this group of spots. On May 9 we photographed on the east limb a group of circular interlacing arches such as are occasionally seen over newly formed spots, and during the passage of the group across the visible hemisphere there were very brilliant metallic reversals and other manifestations of eruptive activity, besides innumerable absorption markings in $H\alpha$ light intertwined throughout the group. All this activity appears to have subsided during the following month.

Another more striking instance of the persistence of magnetic effects long after every trace of solar disturbance has disappeared occurred in the year 1920. The "very great" storm of March 22, 1920, was associated with a very large spot group passing the central meridian on that date. This group and its associated flocculi were observed during five synodic rotations from January 1 to April 18, and each meridian passage was accompanied by a magnetic storm of "great," "very great," or "moderate" intensity. The spot disturbance and its surrounding flocculi completely subsided during May, yet the magnetic disturbances continued to recur at 27-day intervals for seven more periods; the last disturbance to be identified in this sequence was recorded on November 21 as a "moderate" storm. The interval January 1 to November 21, 1920, is 325 days, or twelve periods of 27.08 days. Allowing for the earth's orbital movement during this interval the equivalent solar period is 25.22 days, or Carrington's rotation period for spots in latitude 10° . The slight difference of period compared with that obtained from the 1921 series does not make the evidence for these sequences less convincing; in his discussion of a very large number of such sequences Maunder has shown that the sidereal period derived from them may vary from 25 days to 26.5 days (*Monthly Notices, R.A.S.*, vol. 65, p. 553).

J. EVERSHED.

Kodaikanal, November 28.

Microscope Illumination and Fatigue.

THE further letter from Mr. H. J. Denham in *NATURE* of December 15, p. 496, does not in any way alter my opinion that the method of varying the intensity of illumination in the microscope described by him is not the best or the most convenient at present available. The use of a monochromatic light-filter does not affect the question, as such an accessory is used or not as may appear desirable in any given circumstances. At this institute several sources of light are installed, the one that is regarded as the most useful in high-power work being the mercury vapour lamp. It is obvious, therefore, that if light-absorbing screens of known opacity are available, nothing further is needed whether the light is monochromatic or otherwise. As I have already stated, such screens as we use here alter the intensity, and not the character, of any visible light which they transmit. If Mr. Denham regards the change of quality of his light as an advantage, I do not think that many microscopists will agree with him or adopt his methods while more efficient ones are at hand.

As to my experience of the value of variable illumination, it is, in my opinion, an essential feature of any good microscopic outfit. In use it is second only in importance to the proper adjustment of the light and sub-stage condenser. Apart from its advantage to the observer in reducing fatigue, it is often possible to use a larger cone of illumination by reducing the